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RELATIVE SUSCEPTIBILITY OF CITRUS VARIETIES TO ATTACK BY GLOEOSPORIUM LIMETTICOLUM (CLAUSEN)

1925

BY

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RELATIVE SUSCEPTIBILITY OF CITRUS VARIETIES TO ATTACK BY GLOEOSPORIUM LIMETTICOLUM (CLAUSEN) [1]

By HARRY R. FULTON

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INTRODUCTION

The lime wither-tip disease is caused by an actively parasitic fungus (*Gloeosporium limetticolum* Clausen) which attacks in their young or tender stages the leaves, stems, flowers, and fruits of the variety of lime known variously as West Indian, Mexican, Common Florida, or Key lime. This disease and the fungus causing it must be definitely distinguished from the longer known "citrus wither tip" and the fungus to which it has been generally attributed, *Colletotrichum gloeosporioides* (Penz.). The latter seems to be in most cases a secondary invader rather than an active pathogen. Clausen [2] has called attention to morphological, cultural, and pathogenic differences in these two fungi. The writer has verified Clausen's main findings in this regard, and concurs in Clausen's view that earlier writers included in somewhat confusing fashion two very different fungi and their effects in their discussions of wither tip of Citrus.[3] This confusion is not altogether surprising in view of the variations which may occur in what is commonly regarded as *Colletotrichum gloeosporioides*,[4] but at the same time the two diseases have many points of difference in their grove manifestation, and the evidence is convincing that the lime wither-tip disease is caused by a distinct species, and not by a strain of *C. gloeosporioides* having unusual pathogenic abilities. Winston,[5] in connection with his studies of citrus tear stain, was unable to find, among numerous strains of *C. gloeosporioides* tested, any indication of active pathogenicity on very young fruits of various citrus species.

Severe losses sustained by growers of limes in southern Florida, especially on the Keys, led to an investigation of the lime wither-tip disease and means of control. Spraying with copper-containing materials, such as Bordeaux mixture or Burgundy mixture, has not proved to be entirely successful, due mainly to the fact that infection spreads very rapidly during rainy weather, especially on very tender new shoots that are just expanding or on the blossom parts or on the fruit when quite small (less than $\frac{3}{16}$ inch in transverse diameter), thus making it difficult or impossible to apply with safety a protective spray-coating at the time when most needed. Secondary drawbacks to spraying may arise from the close and irregular spacing of the lime trees, from the rough topography of much of the land, from the relatively low value of the crop per tree, and from the necessity for special control of scale insects after using copper-containing sprays. Bordeaux mixture plus $\frac{1}{2}$ to 1 per cent oil in the form of emulsion has given more satisfactory results in lime wither-tip control than straight Bordeaux mixture.

It would be very desirable to find some variety of Citrus immune to attack by *Gloeosporium limetticolum* that might be grown as a substitute crop for the West Indian lime, with due consideration of the requirements for citric acid and essential oil production and for beverage use. Accordingly, a rather comprehensive investigation was undertaken along this line, with the hope that it might serve as a basis for further work by horticulturists, plant breeders, or plant pathologists looking toward the final solution of the lime wither-tip problem through

[1] Received for publication June 23, 1924; issued June, 1925.

[2] CLAUSEN, R. E. A NEW FUNGUS CONCERNED IN WITHER TIP OF VARIETIES OF CITRUS MEDICA. Phytopathology 2: 217–234, illus. 1912.

[3] ROLFS, P. H. WITHER-TIP AND OTHER DISEASES OF CITRUS TREES AND FRUITS CAUSED BY COLLETOTRICHUM GLOEOSPORIOIDES. U. S. Dept. Agr., Bur. Plant Indus. Bul. 52, 20 p., illus. 1904.

[4] BURGER, O. F. VARIATIONS IN COLLETOTRICHUM GLOEOSPORIOIDES. Jour. Agr. Research 20: 723–736, illus. 1921.

[5] WINSTON, J. R. TEAR-STAIN OF CITRUS FRUIT. U. S. Dept. Agr. Bul. 924, 12 p., illus. 1921.

the finding of a satisfactory substitute citrus variety, to be propagated by budding, by cuttings, or from seed as might prove most desirable.

The ideal would be to find a naturally immune or very highly resistant individual or race in present plantings of the West Indian lime, which is practically always propagated from seed, and so might offer possibilities along this line. The writer has observed certain differences in incidence of the disease that might indicate individual difference in susceptibility, but he has not yet observed a tree that seemed satisfactorily resistant under very severe infection conditions. Such may possibly exist somewhere, and its discovery would mean the quick reestablishment of the lime industry on a better basis in territory invaded by the lime wither-tip disease, where general economic conditions are favorable.

NATURAL INFECTION IN GROVES

That the disease is very closely confined to the West Indian variety of lime is shown by general field observations during many seasons in various parts of Florida, where the West Indian lime seems to be universally affected but where varieties of orange, grapefruit, lemon, tangerine, mandarin, citron, and even such lime varieties as Kusaie, Woglum's Seedless, Buena Vista, Tahiti, and Persian are not affected when growing in close proximity to diseased West Indian limes. The only other variety observed to be affected under natural conditions has been the Dominican Thornless (or Spineless) lime, which supposedly originated as a sport from the West India lime.[6]

FIELD TESTS

During three seasons, 1919, 1920, and 1922, field tests were made on the March growth of various citrus varieties, species, and related genera to determine possible susceptibility to the lime wither-tip disease. These tests were made on property where the disease existed naturally on West Indian and Thornless limes. All of the tested trees were within 200 feet of such naturally infected lime trees, and yet no natural infection has been observed on them during the tests or during two subsequent seasons. The inoculum was a spore suspension, usually from freshly sporulating lesions on lime shoots, but sometimes from artificial cultures. Inoculations were made by wrapping cotton swabs lightly around the very tender shoots (usually 1 to 4 inches long, with many leaves in very susceptible stages), and covering for two days with paraffin paper. Control inoculations were made for every series on susceptible limes to determine the potency of the inoculum, and favorableness of condition, and water-blank controls were also made on the limes to determine what part of the observed infection might have resulted from spores naturally present on the plant surfaces. The indications were that these last played a minor part during ordinary dry weather, as might be expected, since the shoots chosen had very recently begun to develop, and since the Gloeosporium spores depend on dew drip or rain for their distribution.

The results are given in Table I. The only evidence of any susceptibility is shown by the West Indian lime and by Dominican Thornless lime, which is a derivative of it. The tests included a representative lot of commercial citrus varieties, as well as a considerable range of unusual citrus varieties, species, and a few related genera. Puncturing did not increase materially the percentage of susceptibility for the West Indian and the Thornless limes, indicating that the shoots selected for the tests were young enough to have practically maximum susceptibility without artificial injury.

The field evidence is thus very strong that the lime wither-tip disease is closely restricted to the West Indian types of lime.

GREENHOUSE INOCULATIONS

Potted plants, three of each variety, were cut back severely so as to induce the sprouting of a considerable number of young shoots. When these were barely starting the plants were placed in an inoculation case where the air was kept practically saturated with moisture. Spore suspensions of *G. limetticolum* were atomized over these plants 10 times during 21 days. Then the young shoots, which had attained several inches in length, but were somewhat etiolated and quite succu-

[6] "In 1892 on Shelford [probably intended for "Shawford"] Estate, Dominica, a lime tree was noticed without the usual formidable spines. Seeds from this apparent "sport" were collected and sown. Some 75% came true and a plot of spineless limes forms an interesting feature of the Dominican Botanic Garden. The plants in this plot are now bearing heavily, and the Curator reports that 80 to 90% of the seedlings raised are coming true." Agricultural News, Vol. 1, No. 3, May 24, 1902, p. 38.

TABLE I.—*Field tests by artificial inoculation for susceptibility to Gloeosporium limetticolum*

Varieties tested	Unpunctured					Punctured				
	Number of tests	Total shoots	Per cent positive	Per cent doubtful	Per cent negative	Number of tests	Total shoots	Per cent positive	Per cent doubtful	Per cent negative
LIMES										
West Indian	8	53	89	0	11	3	20	90	0	10
Dominican Thornless	6	91	86	0	14	2	9	89	0	11
Tahiti	8	81	0	0	100	1	5	0	0	100
Rangpur	5	60	0	0	100	1	3	0	0	100
LIME HYBRIDS										
Limequat	8	87	0	0	100	0				
Faustrime	4	68	0	0	100	1	3	0	0	100
CITRON										
Citron of commerce	3	14	0	0	100	0				
LEMONS										
Kenedy	4	35	0	0	100	2	13	0	0	100
Villa Franca	6	44	0	0	100	3	16	0	0	100
Lamb	6	54	0	0	100	3	17	0	0	100
Dwarf Chinese	2	17	0	0	100	0				
Sweet lemon	2	13	0	0	100	0				
GRAPEFRUIT										
Marsh	7	62	0	0	100	3	15	0	0	100
Silver cluster	2	15	0	0	100	0				
Walters	5	50	0	0	100	3	14	0	0	100
Conner's Prolific	1	6	0	0	100	2	5	0	0	100
Pernambuco	4	34	0	0	100	0				
Leonardi	5	51	0	0	100	1	8	0	0	100
Foster	2	21	0	0	100	0				
Royal	3	34	0	0	100	0				
Pink Marsh (Thompson)	1	8	0	0	100	0				
Sour grapefruit	1	17	0	0	100	0				
ORANGES										
Valencia	7	60	0	0	100	3	20	0	0	100
Pineapple	3	27	0	0	100	0				
Parson Brown	4	41	0	0	100	1	11	0	0	100
Ruby Blood	2	15	0	0	100	0				
Maltese	4	31	0	0	100	0				
Homosassa	4	40	0	0	100	2	10	0	0	100
Lue	2	16	0	0	100	0				
Washington Navel	1	14	0	0	100	0				
Mediterranean Sweet	1	11	0	0	100	0				
Seedling orange	1	14	0	0	100	0				
MANDARIN GROUP										
Tangerine	6	60	0	0	100	0				
Mandarin	1	13	0	0	100	0				
Satsuma	4	34	0	0	100	2	10	0	0	100
King	2	16	0	0	100	2	10	0	0	100
Temple	2	40	0	0	100	0				
Cleopatra	2	18	0	0	100	0				
VARIOUS HYBRIDS										
Tangelo varieties	8	95	0	0	100	3	20	0	0	100
Tangelolo, pink	1	18	0	0	100	0				
Faustrimedin	0					1	1	0	0	100
Natsumikan	4	49	0	0	100	0				
Citrangequat	1	3	0	0	100	0				
Tangor	2	20	0	0	100	0				
Siamelo	2	43	0	0	100	0				
Washington Navel × grapefruit	2	19	0	0	100	0				
VARIOUS CITRUS										
Sour orange	3	27	0	0	100	1	8	0	0	100
Bittersweet orange	2	23	0	0	100	0				
Sweet Bittersweet orange	2	24	0	0	100	0				
Myrtle Leaf orange	2	25	0	0	100	0				
Rough Lemon	5	32	0	0	100	3	16	0	0	100
Citrus mitis	4	29	0	0	100	1	4	0	0	100
RELATED GENERA										
Nagami kumquat	3	28	0	0	100	0				
Marumi kumquat	2	21	0	0	100	2	10	0	0	100
Chalcas exotica	1	7	0	0	100	0				
Severinia buxifolia	2	20	0	0	100	0				

lent, were punctured, dipped in a strong suspension of lime wither-tip spores, wrapped in wet cotton swabs, and replaced in the inoculation case for four days. Final observations were made eight days after removal from the inoculation case. Included in this test were West Indian lime, Kusaie lime, Sweet lime, Ponderosa lemon, seedling California lemon, Gold Medal grapefruit, Silver Cluster grapefruit, Pineapple orange, seedling round orange, Mandarin orange, Dancy tangerine, Sour orange, Cuban tangelo, and Mohawk orangelo.

The West Indian lime plants had all of the young shoots destroyed by wither tip during the first part of the experiment and no new growth was made. None of the other varieties was affected by the wither-tip disease during the progress of this very severe test.

In another somewhat similar test an inoculation chamber was used at an average temperature of 80° F. with the air practically saturated. Three plants of each variety were selected, all having very tender shoots with leaves just beginning to expand. These were punctured, and the inoculum, a heavy suspension of spores from lime lesions, was applied with cotton swabs. Further applications of spore suspensions were made with an atomizer on the second and the fifth day. On the sixth day the plants were removed from the inoculation chamber.

The West Indian lime plants developed 100 per cent infection. No infection developed on other varieties in the test, namely, Sweet lime, Rangpur lime, Kenedy lemon, Ponderosa lemon, seedling California lemon, Dancy tangerine, Mandarin orange, Pineapple orange, seedling Florida orange, Sour orange, Silver Cluster grapefruit, Gold Medal grapefruit.

Tests were undertaken to determine the susceptibility of a large number of plants grown under greenhouse conditions. Most of these were 1 to 3 years old, well branched, and furnishing flushes of growth that seemed normal. The inoculum was usually a freshly made spore suspension from an actively sporulating wither-tip lesion on the West Indian lime, but in some cases the spores were from pure cultures of *G. limetticolum*. Very young shoots were selected that had leaves young enough to develop infection if the plant was susceptible. In some tests the leaves were punctured some 50 times each. The spore suspension was applied on wet cotton, the shoot wrapped in paraffin paper, and the plant placed in a large glass-enclosed inoculation chamber over wet sand. Observations were made after 7 to 10 days. Control tests were carried on with each series to show the pathogenicity of the inoculum on West Indian lime. The results of these tests are summarized in Table II

TABLE II.—*Greenhouse tests by artificial inoculation for susceptibility to Gloeosporium limetticolum*

Varieties tested	Unpunctured					Punctured				
	Number of tests	Total shoots	Per cent positive	Per cent doubtful	Per cent negative	Number of tests	Total shoots	Per cent positive	Per cent doubtful	Per cent negative
LIMES										
West Indian	23	74	57	11	32	39	109	93	4	3
Dominican Thornless	3	12	100	0	0	5	19	100	0	0
Persian	4	13	0	5	95	11	28	0	18	82
Kusaie	4	24	0	0	100	13	70	0	0	100
Sour Lime No. 7338 [a]	2	6	0	0	100	8	19	0	0	100
Sweet	3	19	0	0	100	4	26	0	4	96
Rangpur	9	41	0	2	98	19	80	0	4	96
LIME HYBRIDS										
Limequat	7	11	0	9	91	8	18	0	11	89
Faustrime	19	118	0	0	100	42	302	0	9	91
CITRONS										
Citrus medica (Susceptible strains)	14	31	0	13	87	34	87	23	21	56
Citrus medica (other strains)	17	35	0	0	100	38	84	0	20	80
Sour Citron No. 7425 [a]	5	9	0	22	78	6	25	0	8	92
Etrog Citron	3	10	0	0	100	9	20	0	5	95

[a] Serial numbers of the Office of Crop Physiology and Breeding Investigations Bureau of Plant Industry, U. S. Department of Agriculture. The writer acknowledges his indebtedness to this office for a large number of the unusual varieties included in the present investigation.

TABLE II.—*Greenhouse tests by artificial inoculation for susceptibility to Gloeosporium limetticolum*—Continued

Varieties tested	Unpunctured					Punctured				
	Number of tests	Total shoots	Per cent positive	Per cent doubtful	Per cent negative	Number of tests	Total shoots	Per cent positive	Per cent doubtful	Per cent negative
LEMONS										
Eureka	1	1	0	0	100	2	6	0	0	100
Lisbon						1	2	0	0	100
California Seedling	4	5	0	20	80	8	15	0	20	80
Villa Franca	1	1	0	0	100	3	6	0	33	67
Kenedy	1	2	0	0	100	2	8	0	0	100
Dwarf Chinese	4	9	0	11	89	11	16	0	6	94
Ponderosa	3	5	0	0	100	12	44	0	5	95
Malta Lemon	3	4	0	0	100	6	13	0	8	92
Lemon sp	4	8	0	0	100	6	13	0	34	66
GRAPEFRUIT										
Marsh	3	19	0	0	100	3	19	0	0	100
Silver Cluster	1	3	0	0	100	3	11	0	0	100
Gold Medal	1	3	0	0	100	1	5	0	0	100
Chinese Pummelo No. 11213 [a]	2	6	0	0	100	5	15	0	7	93
Sour Pomelo No. 7440 [a]	1	1	0	0	100	6	9	0	11	89
Grapefruit seedlings	7	22	0	0	100	20	74	0	9	91
ORANGES										
Valencia	2	12	0	0	100	1	6	0	0	100
Pineapple	2	4	0	0	100	4	11	0	0	100
Parson Brown	3	16	0	0	100	3	16	0	0	100
Mediterranean Sweet	2	18	0	0	100	3	14	0	0	100
Ruby Blood	3	20	0	0	100	7	18	0	0	100
China Sweet	3	7	0	0	100	5	12	0	8	92
Golden Ring	1	5	0	0	100	2	10	0	0	100
Miscellaneous	1	1	0	0	100	17	41	0	2	98
Florida Seedling	2	18	0	0	100	4	14	0	0	100
MANDARIN GROUP										
Tangerine	2	6	0	0	100	6	15	0	0	100
Mandarin	2	15	0	0	100	8	34	0	0	100
Satsuma	4	11	0	0	100	7	17	0	0	100
King						1	6	0	0	100
Temple						1	10	0	0	100
Clematine	1	5	0	0	100	3	7	0	0	100
C. nobilis	1	3	0	0	100	4	9	0	0	100
VARIOUS HYBRIDS										
Faustrimedin	3	25	0	0	100	5	38	0	5	95
Tangelo varieties	11	49	0	0	100	23	78	0	10	90
Orangelo varieties	1	5	0	0	100	3	11	0	0	100
Citrange varieties	1	7	0	0	100	4	7	0	0	100
Miscellaneous seedling hybrids	1	6	0	0	100	7	28	0	7	93
VARIOUS CITRUS										
Sour orange	2	4	0	0	100	4	17	0	0	100
Bittersweet orange	4	4	0	0	100	8	14	0	0	100
Rough lemon	2	7	0	0	100	4	21	0	0	100
Myrtle-leaved orange						1	2	0	0	100
Citrus sp. Mamis	2	2	0	0	100	3	10	0	10	90
Citrus Caibe or Moi	1	2	0	0	100	4	7	0	0	100
Limon Real						3	4	0	0	100
Citrus mitis	6	14	0	0	100	16	47	0	2	98
Citrus excelsa	9	25	0	0	100	16	40	0	5	95
Citrus hystrix	4	8	0	0	100	4	18	0	6	94
Otaheite orange	4	11	0	0	100	9	43	0	2	98
Double Flowering orange	1	2	0	0	100	2	12	0	0	100
Saigon orange	1	1	0	0	100	5	8	0	12	88
Ladoo orange	3	13	0	0	100	3	7	0	0	100
Kansu orange	3	4	0	0	100	5	14	0	0	100
Ichang lemon	5	14	0	0	100	19	53	0	15	85
RELATED GENERA										
Poncirus trifoliata	2	4	0	0	100	4	10	0	0	100
Nagami kumquat	1	1	0	0	100	8	19	0	16	84
Fortunella crassifolia	3	7	0	0	100	8	30	0	0	100
Microcitrus australis	2	13	0	0	100	8	52	0	6	94
Chaetospermum glutinosum	2	2	0	0	100	5	16	0	0	100

[a] Serial number of the Office of Crop Physiology and Breeding Investigations Bureau of Plant Industry, U. S. Department of Agriculture. The writer acknowledges his indebtedness to this office for a large number of the unusual varieties included in the present investigation.

The cases recorded above as doubtful showed decided death of tissue, but did not develop typical *Gloeosporium limetticolum* sporulation. It is very likely that such lesions were produced by saprophytic organisms that were able to invade and break down tissues under the rather extreme conditions of inoculation. In the writer's opinion these doubtful cases are in all probability negative.

In the case of the citrons, 10 strains or varieties were furnished by the Office of Crop Physiology and Breeding Investigations. Six of these lots did not show any positive evidence of infection by *G. limetticolum*, and they are averaged together in the tabulation. Four other lots did show low percentages of what seemed to be positive, although not perfectly typical infection. This was verified by culturing *G. limetticolum* from the lesions on punctured shoots, and by securing typical infection on limes from such cultures; and on this basis a positive record was made in such cases. However, the absence of any such cases on the unpunctured shoots, and the occurrence on citrus of a large proportion of doubtful lesions in which the presence of *G. limetticolum* could not be demonstrated, would lend support to the view that tender shoots of these citrons are rather subject, under the conditions of the puncture experiments, to invasion by saprophytic fungi among which *G. limetticolum* may sometimes be found. Certainly these citrons, classed as susceptible, are affected with far less frequency than the susceptible varieties of limes, and the lesions recorded as positive did not have all the typical features of lime wither tip.

Besides these somewhat questionable results from certain citrons, there is no positive susceptibility except in the group of limes, and among the varieties tested in this group the susceptibility is sharply confined to the West Indian lime and to Dominican Thornless lime.

GENERAL DISCUSSION

Clausen,[7] in his description of *G. limetticolum*, gives three host plants, *Citrus medica* var. *acida* Hook. (=*C. aurantifolia* Sw., and includes the West Indian lime which is referred to by Clausen as sour lime), *C. limetta* Risso, and *C. limonis* L. Clausen explains that the last two were artificially infected in greenhouses and that "the report of pathogenic properties on the sweet lime, *C. media* var. *limetta*, is according to C. O. Smith who is working at Whittier, Calif., with a strain of fungus supplied by the writer." The strain of Sweet lime used in the present investigation did not give positive results in 7 tests including 45 shoots, punctured and unpunctured as well as in 2 special tests of 3 plants each. Clausen reports only 2 tests of lemons (*C. limonis* L.=*C. limonia* Osb.) with *G. limetticolum*. Two trees were used in each; 1 test was negative for both trees, in the other test one tree developed "an infection of three young leaves, the other lemon, as well as the control, was not affected in any way." He further states, "the extent of parasitism on the lemon was not fully demonstrated in the experiments, but the parasitism in the one positive case was unmistakable." Clausen's inoculation tests included: 19 on sour (West Indian) lime of which 13 were positive, 4 on lemon of which 3 were negative, 8 negative on sweet orange, 8 negative on sour orange, 7 negative on grapefruit, and 4 negative on tangerine orange. Adopting the view that the sour lime, the sweet lime, and the lemon are all varieties of *C. medica* L., he states in his summary that the wither-tip fungus in his artificial infection attacked only forms and varieties of this one species.

The present investigation gives much more extensive evidence that most citrus types are immune to attack by *G. limetticolum*. It casts doubt on the reported susceptibility of sweet lime and lemon, and raises the question of whether or not certain citrons may have slight susceptibility when wounded.

It is interesting to note that commercial plantings of the West Indian lime are commonly made from seedlings. These have remarkable similarity in their general characteristics, and all seem to be highly susceptible to the wither-tip disease. A constant lookout has been kept in affected groves, and special tests of seedlings have been made for individuals immune to the disease. As yet no such individual has been found. It is possible that such individuals do exist, and the prompt discovery of one plant with high resistance or complete immunity would mean a quicker and more satisfactory solution of the wither-tip-control problem than the substitution of some other citrus variety that is immune, or the development of some new type by hybridizing.

[7] CLAUSEN, R. E. Op. cit. p. 232.

The Dominican Thornless lime seems almost as susceptible as the ordinary West Indian lime. The percentages of experimental infection were very much the same for these two varieties; the experimental lesions on the former usually developed more rapidly and extensively than on the latter; but the natural grove infection seemed somewhat less severe. This thornless type, commonly supposed to be a sport from the West Indian lime, is quite distinct from it in fruit, leaf, and stem characteristics. Seedlings from it seem to be more variable than those from the West Indian lime. Keys [8] has reported a peculiar dying and shedding of the flowers and very young pistils, due to an aborted condition of the stigmas, which might be confused with wither-tip attack.

Is susceptibility to attack by *G. limetticolum* a dominant character in inheritance? The practically universal susceptibility of West Indian lime seedlings would support a positive answer if the embryos result from true fertilization. On the other hand, the two hybrids tested that have West Indian lime parentage are nonsusceptible. Certainly the Dominican Thornless lime is very susceptible, and is the only citrus variety besides the West Indian lime out of several scores in the present tests for which there is unquestioned evidence of high susceptibility. It will be interesting and important from the standpoint of genetics to test the susceptibility of a considerable number of seedlings of the Dominican Thornless lime, as well as more hybrids of the West Indian lime.

SUMMARY AND CONCLUSIONS

The evidence here presented includes field observations on a large number of citrus varieties, species, and related genera growing near lime trees that were always severely infected with lime wither tip, as well as the results of artificial inoculations made during three seasons on wounded and on unwounded tender shoots both in groves in Florida and in a greenhouse near Washington, D. C. The West Indian lime and the Dominican Thornless lime have constantly shown a high degree of susceptibility to infection by *Gloeosporium limetticolum* of very young leaf, stem, and fruit tissue. These two varieties are probably closely related to each other. None of the other varieties of limes tested has given undoubted indication of susceptibility. Certain strains of citron (*Citrus medica* L.) have shown atypical invasion of wounded tissue by *G. limetticolum* in a comparatively small percentage of cases under greenhouse inoculation. Other varieties of limes (*C. aurantifolia* Sw.) as well as the majority of varieties of *C. medica*, have been absolutely immune to infection under the very severe conditions of the tests. This also holds true for certain first-generation hybrids having West Indian lime parentage that were subjected to test, and for representative varieties of round orange (*C. sinensis* Osb.), for grapefruit (*C. grandis* Osb.), for lemon (*C. limonia* Osb.), for kid-glove oranges (*C. nobilis* var.), and for a considerable number of miscellaneous species of Citrus and genera related to Citrus.

The close restriction of susceptibility in so far as is known practically to two very closely related seedling horticultural varieties of lime gives promise for successful substitution of other types of lime for the susceptible ones as a means of ultimately escaping losses from the disease, and points to the availability of a wide range of immune breeding stock as a basis for hybridization. Susceptibility seems not to be a dominant character in first-generation hybrids with other citrus species, but the natural seedlings of the West Indian lime, practically without exception, are highly susceptible. However, there is the possibility that a natural seedling may be found possessing immunity and having the desired characters of the West Indian lime. Such a find would possibly result in most effective and satisfactory control of the very destructive lime wither-tip disease.

[8] [KEYS, A.] ABNORMAL FLOWERS OF THE SPINELESS LIME. Rept. Agr. Dept. Dominica [Brit. West Indies] 1922–23: 23–24. 1923.